Evaluating Certification Authority Security

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GTE

INTERNETWORKING

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Presentation Outline

- CA security requirements
- Adversaries
- Threats
- Countermeasures
- Cryptographic Modules
- Summary

The CA Security Requirement

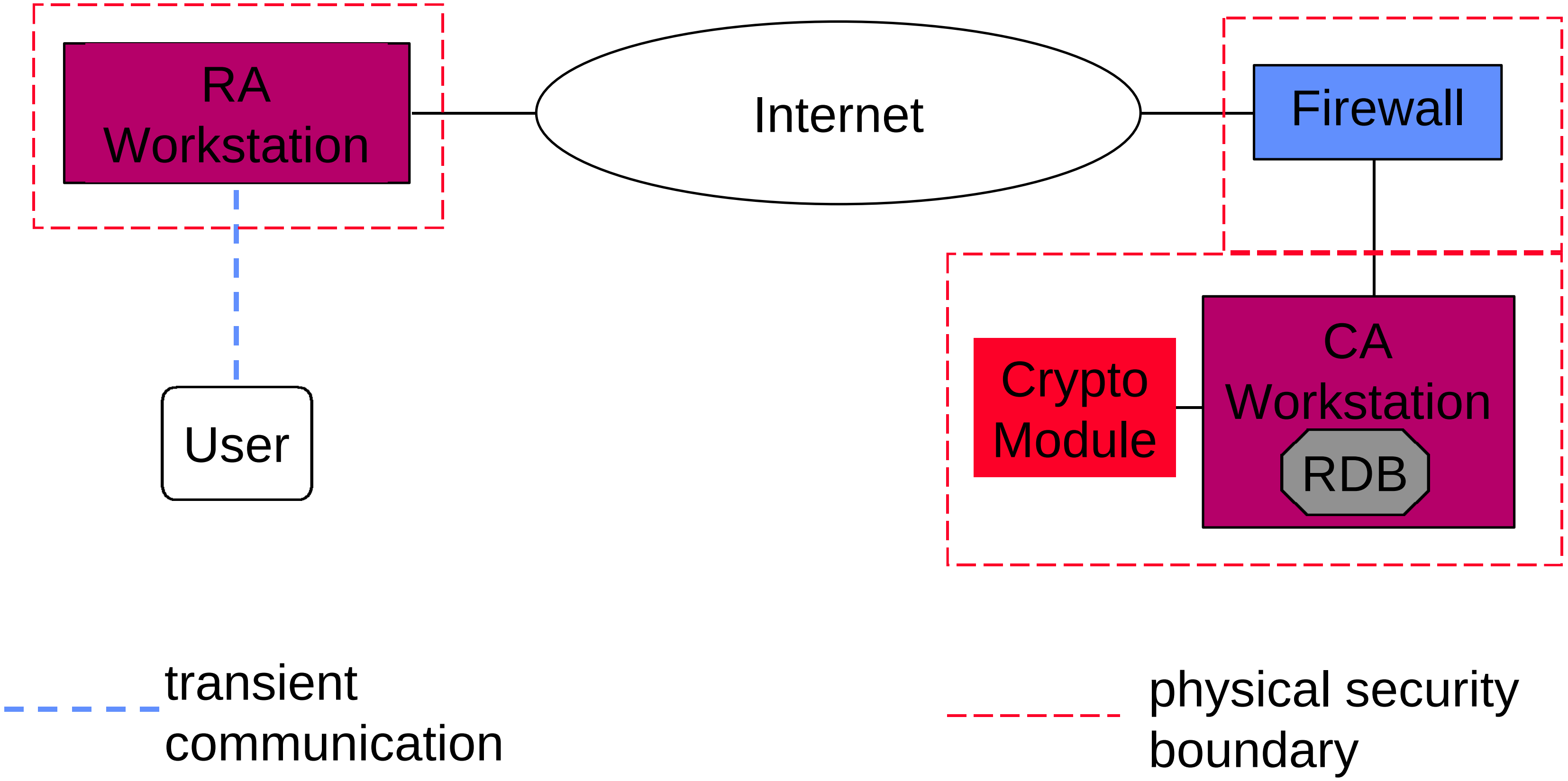
Establish and maintain an accurate binding between attributes and a public key in a certificate

Derived Security Requirements

- Protection of CA private keys
  - confidentiality in the face of a wide range of attacks
  - support for polyinstantiation
  - support for key recovery
- Validation of certificate issuance requests
  - user/organization identification
  - verification of certificate syntax against rules for a specific CA or RA (basic certificate fields and extensions)
- Validated certification revocation requests
- Timely CRL distribution*

*requires use of a directory system, largely outside control of the CA

Typical CA System Components



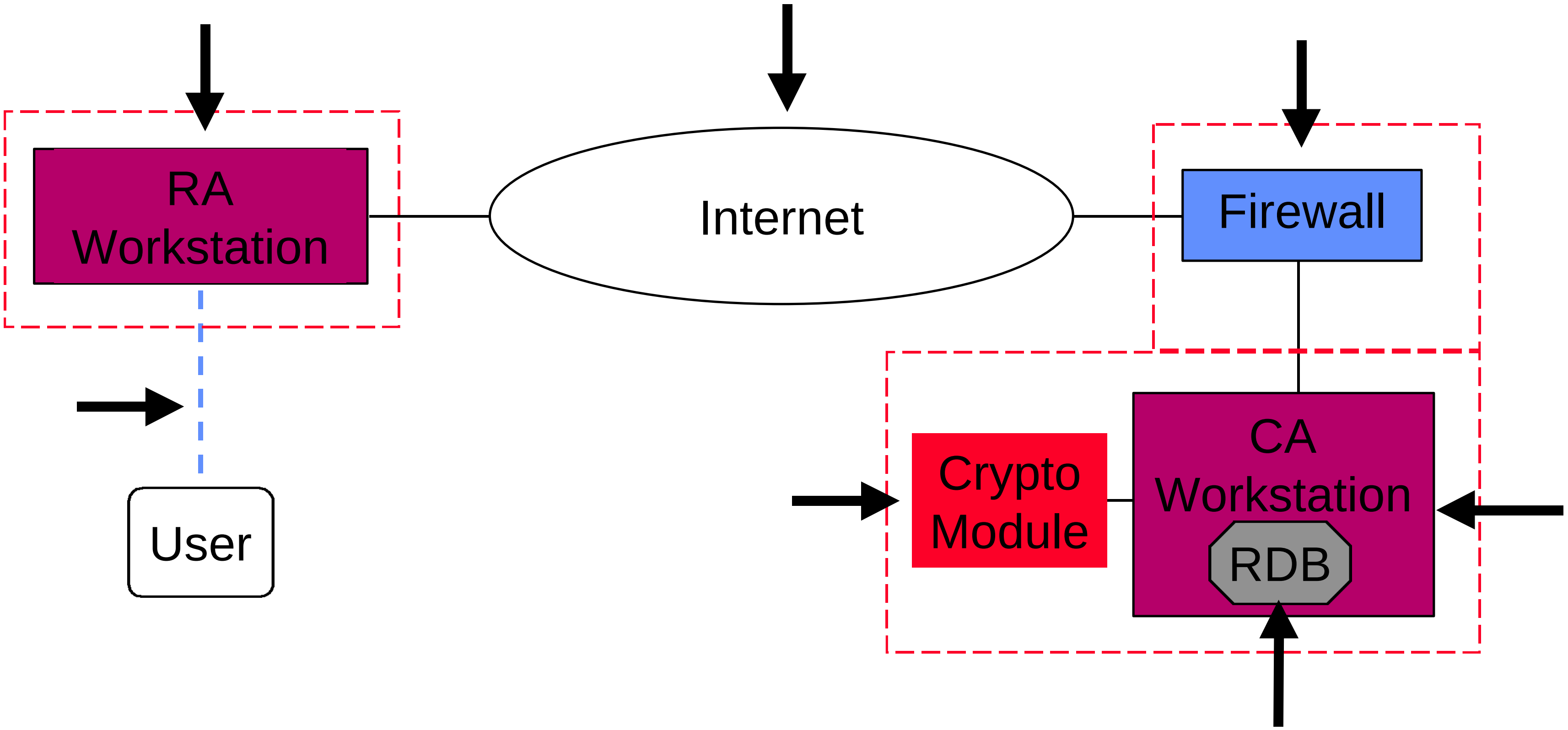
Adversaries & Capabilities

- Hackers
  - motivated by recognition (not averse to detection)
  - software-based attacks
  - external access
- Compromised employees
  - motivated by retribution, greed, ... (averse to detection)
  - internal access
  - may employ software, hardware, physical attacks
- Criminals
  - motivated by greed (averse to detection)
  - external or internal access (bribe employees, break in, ...)
  - may employ software, hardware, physical attacks

Attacks Against CAs

- Passive and active wiretapping
  - user/RA path
  - RA/CA path
- Personnel compromise
- CA workstation attacks
  - OS penetration
  - CA software or database manipulation
- Crypto module attacks
  - simple physical tampering
  - module theft/swapping
  - close-in attacks (TEMPEST, temperature, timing analysis, differential fault analysis, ...)

Attack Points



Protecting CAs

- Physical security
- Personnel security
- Procedural security
- OS and application security
- Network security
- Crypto module security

Countermeasures

- Locks, sensors, guards, guns, dogs, ...
- Personnel background checks
- Audit trails
- Multi-party authorization
- Certificate syntax filtering against rules
- Operating system security
- Software configuration control
- Signed/encrypted RA-CA communication
- Firewalls
- Crypto module security

Crypto Module Security

- Potentially, a good crypto module can significantly reduce vulnerabilities due to personnel, procedural, physical, and computer security shortcomings
- Most crypto modules in use today do not go very far towards realizing this potential, and none are ideal
- Implementation options for crypto modules
  - software
  - generic crypto hardware (e.g., PC and smart cards)
  - hardware specialized for CA use

Software Crypto

- Advantages
  - low cost
  - no hardware interface problems
- Limitations
  - vulnerable to CA key compromise via software or physical attacks on workstation
  - poor key generation (no hardware RNG)
  - poor performance
  - poor audit trail security
  - low entropy PINs, PIN exposure to workstation
  - vulnerable to personnel (RA/CA) security compromise
  - vulnerable to close-in monitoring attacks?

Generic Crypto

- Advantages
  - modest cost
  - keys protected from compromise of workstation software or physical attacks against the workstation
  - hardware RNG for key generation
  - multi-party authorization possible with split-signing systems
- Limitations
  - poor support for CA key polyinstantiation & recovery
  - low entropy PINs, PIN exposure to workstation
  - vulnerable to close-in monitoring attacks
  - no certificate syntax validation
  - no builtin audit
  - vulnerable to theft & device swapping attacks

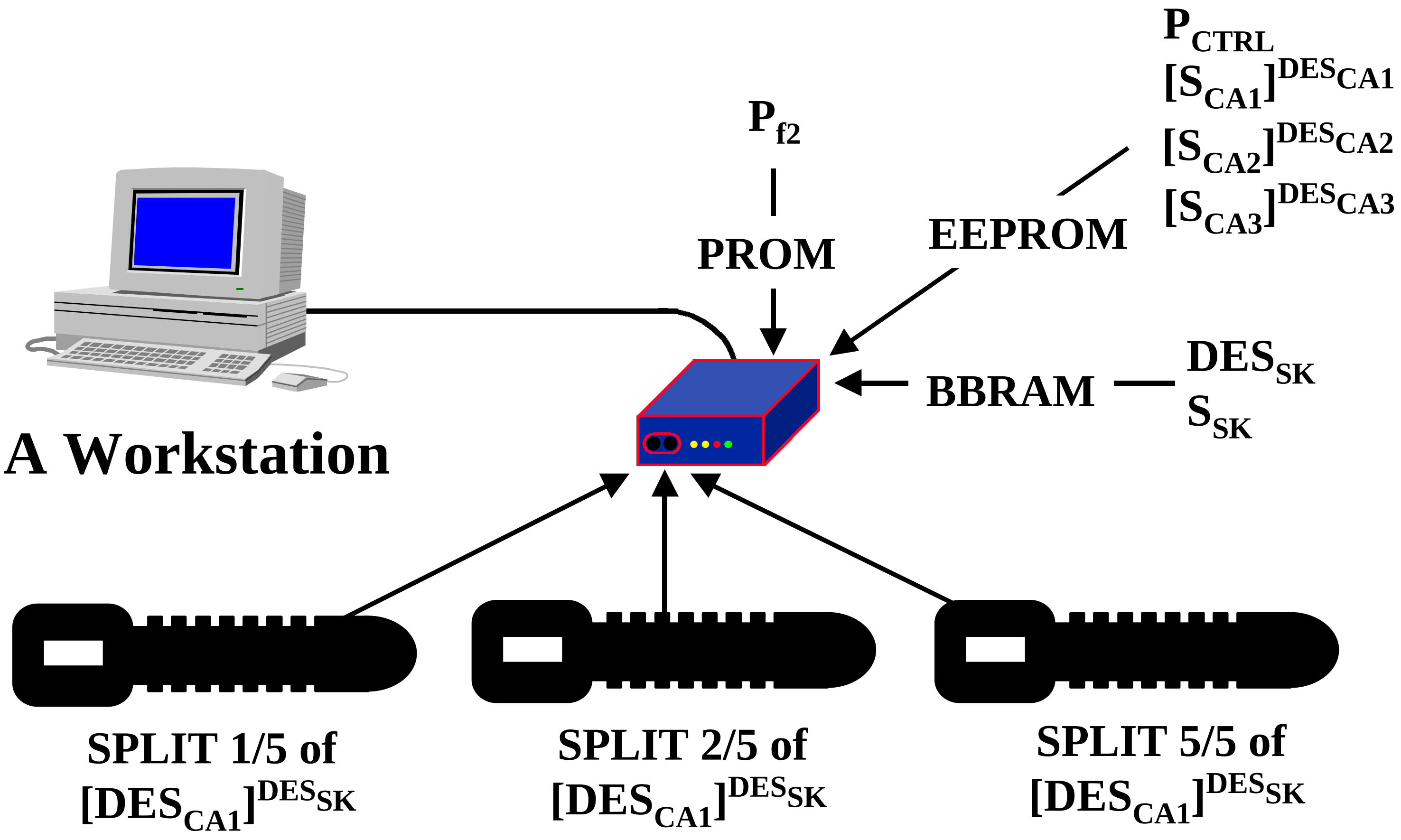
Specialized Crypto

- Advantages
  - keys protected from compromise of workstation software or physical attacks against the workstation
  - hardware RNG for key generation
  - multi-party authorization via high entropy keys
  - secure polyinstantiation/recovery for CA keys
  - protection against close-in monitoring/tampering
  - certificate syntax validation (RDB)
  - secure audit
- Limitations
  - higher device cost
  - limited certificate/CRL rule checking (in current devices)

CA Security Recommendations

- Establish high quality personnel, physical, and procedural security standards for CA operations
- Use a crypto module specialized for support of CA functions, with suitable provisions for CA key recovery, polyinstantiation, & multi-party authorization
- Employ a high assurance workstation for the CA
- Protect RA-CA communications with cryptography

Keys to the Right, Keys to the Left ...



CA Workstation

P_{f2}

PROM

EEPROM

P_{CTRL}

$[S_{CA1}]^{DES_{CA1}}$

$[S_{CA2}]^{DES_{CA2}}$

$[S_{CA3}]^{DES_{CA3}}$

BBRAM

DES_{SK}

S_{SK}

SPLIT 1/5 of $[DES_{CA1}]^{DES_{SK}}$

SPLIT 2/5 of $[DES_{CA1}]^{DES_{SK}}$

SPLIT 5/5 of $[DES_{CA1}]^{DES_{SK}}$

Summary

- The fundamental security requirement for CAs is simple to state, but hard to achieve in the face of a wide range of attack scenarios
- Software crypto for CAs is highly vulnerable
- Hardware crypto can limit the range of attacks against CA keys, but generic crypto devices still leave CAs vulnerable to many attacks
- Specialized hardware crypto, designed for CA support, offers the greatest potential for high assurance CA operation, but it’s not a complete solution
- Specialized crypto may be most important in highly distrubuted CA environments, where personnel, physical and procedural security is worst!